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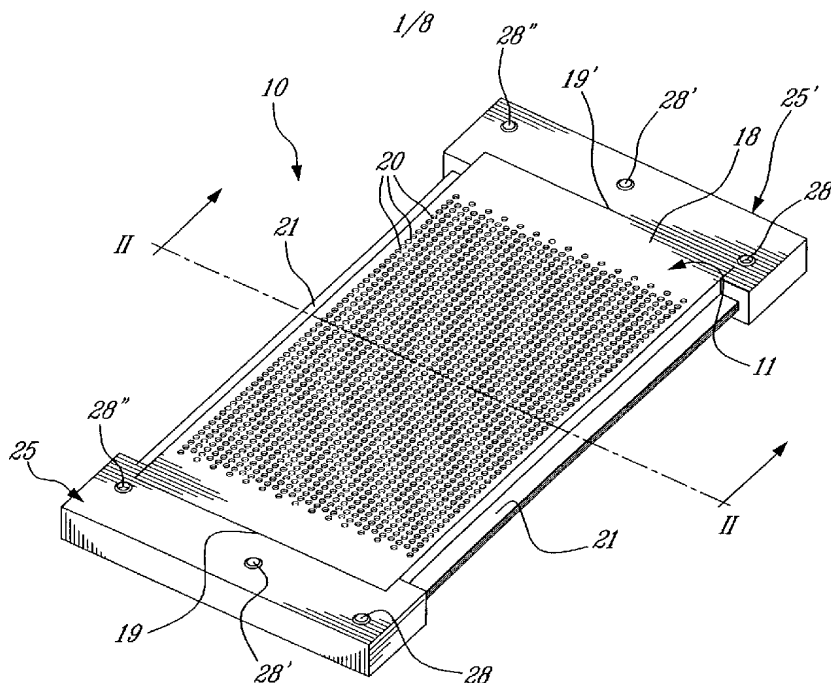
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(54) Title: BIPOLAR SEPARATOR PLATE ASSEMBLY FOR A FUEL CELL



(57) Abstract: A liquid cooled bipolar separator plate assembly for use in the construction of a fuel cell, is described. The bipolar separator plate assembly comprises a pair of rectangular perforated distributor plates disposed in spaced parallel relationship by an intermediate structure. This structure may be comprised of two separated plates of undulated cross-section with each plate defining longitudinal peaks and valleys. The separator plates are also rectangular plates and are interconnected in back-to-back relationship at the peaks to form a group of inner adjacent cooling liquid channels therebetween and a first and second group of outer gas channels on opposed outer sides of the interconnected separator plates. The peaks on the outer sides are secured to a respective one of the perforated distributor plates. The perforated distributor plates and separator plates are sealingly secured together along

their opposed side edges. The inner cooling liquid channels and the outer gas channels are opened at opposed end edges of the interconnected separator and distributor plates. An end manifold is sealingly secured to each of the opposed end edges. The end manifolds each have interconnecting conduits to interconnect the cooling liquid channels together and the first and second groups of gas channels, respectively, together.



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## BIPOLAR SEPARATOR PLATE ASSEMBLY FOR A FUEL CELL

TECHNICAL FIELD

The present invention relates to a liquid cooled  
5 bipolar separator plate assembly for use in the construction  
of fuel cells.

BACKGROUND ART

In the construction of fuel cells, stacks of  
10 bipolar separator plates are utilized to provide  
distribution of hydrogen gas and fresh oxidant throughout  
the stack as is necessary to create a potential across  
interposed electrode sheets. A cooling liquid, such as  
water, is also circulated through the stack whereby to  
15 provide good heat dissipation. A major problem with bipolar  
separator plate designs is that they are very expensive to  
fabricate and because fuel cell utilizes a large quantity of  
these plates the stacks are very expensive to produce.

Various manufacturing methods and designs have  
20 been attempted whereby to reduce the cost of fabrication of  
these plates. Commonly, many of these plates are  
constructed of stainless steel and a photo-etching process  
is utilized to form channels in the plates to distribute gas  
thereover and cooling liquid on an opposed side. Because  
25 these conduits are very small it is difficult to assemble  
the plates and therefore expensive to fabricate the fuel  
cell. Furthermore, because these channels have a serpentine  
configuration to distribute the gas and the cooling liquid,  
gas and cooling liquid pressure loss occurs from input to  
30 output and this is particularly due to the resistance in the  
fluids having to flow around many corners of the serpentine  
channel. Also, the concentration of gas throughout the gas  
distribution channels is not uniform and the result is that  
the cell is more efficient in the input region of the plates  
35 where the gas is fed in. A possible solution to this  
problem would be to have multiple inputs throughout the

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plates leading to the channel, but this gives rise to the risk of leakage and renders the manufacturing costs even more expensive.

Laser etching techniques have also been attempted  
5 but it was found that the stainless steel plates deform under the intense heat of the laser beam and a suitable quality is not achievable by this method. Another method is to machine the channels within the stainless steel plates but this is a slow process and it is required to change the  
10 drill bits frequently due to the hardness of the stainless steel. Also, with the machining process it was found necessary to remove burrs that form during the machining. The water jet etching technology also did not prove adequate and caused deformation of the plates and is not at all  
15 suitable.

#### SUMMARY OF INVENTION

It is therefore a feature of the present invention to provide a liquid cooled bipolar separator plate assembly  
20 which substantially overcomes the above disadvantages.

Another feature of the present invention is to provide a liquid cooled bipolar separator plate assembly which is economical to produce, provides good distribution of gas and oxidant as well as the cooling liquid.

25 Another feature of the present invention is to provide a liquid cooled bipolar separator plate assembly which is easy to assemble and easy to interconnect in stacked form to form fuel cells.

According to the above features, from a broad  
30 aspect, the present invention provides a liquid cooled bipolar separator plate assembly for a fuel cell. The assembly comprises a pair of rectangular perforated distributor plates disposed in spaced parallel relationship by an intermediate structure. The intermediate structure  
35 has inner cooling liquid channels and a first and a second group of outer exposed gas distribution channels on opposed

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outer sides of the intermediate structure. The outer channels are separated by ridges which are secured to a respective one of the perforated distributor plates. The perforated distributor plates and intermediate structure are sealingly secured together along their opposed side edges. The inner cooling liquid channels and the outer gas channels are opened at opposed end edges of the intermediate structure and distributor plates. An end distribution manifold is sealingly secured to each of the opposed end edges. The end manifolds each have interconnecting conduits to interconnect the cooling liquid channels together and the first and second groups of gas channels, respectively, together.

According to a further broad aspect of the present invention the intermediate structure is constituted by two rectangular separator plates of undulated transverse cross-sections with each plate defining longitudinal peaks and valleys. The separator plates are interconnected in back-to-back relationship at the peaks to form the inner cooling channels therebetween and disposed in parallel side-by-side relationship.

According to a further broad aspect of the present invention the gas distribution channels are defined by the valleys between the peaks with the peaks constituting the ridges.

#### BRIEF DESCRIPTION OF DRAWINGS

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a liquid cooled bipolar separator plate assembly constructed in accordance with the present invention;

FIG. 2 is a transverse section view through section lines II-II of Figure 1;

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FIG. 3 is a perspective view of the perforated distributor plate;

FIG. 4 is an end view of Figure 3;

FIG. 5 is a perspective view of the undulated separator plate;

FIG. 6 is an end view of Figure 5;

FIG. 7 is an assembly view of the separator plates and distributor plates welded together;

FIG. 8 is an end view of Figure 7;

FIG. 9 is a perspective view of the end manifold;

FIG. 10A is a cross-section view along cross-section lines X-X of Figure 9;

FIG. 10B is a cross-section view along cross-section lines Y-Y of Figure 9;

FIG. 11 is a top plan view of the end manifold;

FIG. 12A is a cross-section view along cross-section lines A-A of Figure 11;

FIG. 12B is a cross-section view along cross-section lines B-B of Figure 11;

FIG. 12C is a cross-section view along cross-section lines C-C of Figure 11;

FIG. 13 is a side view showing a plurality of separator plate assemblies interconnected together;

FIG. 14A is a section view along section lines A-A of Figure 13;

FIG. 14B is a section view along section lines B-B of Figure 13; and

FIG. 15 is a perspective view of the bipolar separator plate assembly of Figure 1 interconnected together in a stack.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, and more particularly to Figures 1 and 2, there is shown generally at 10 a liquid cooled bipolar separator plate assembly for use

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in the construction of fuel cells, not shown. The bipolar separator plate assembly 10 comprises a pair of rectangular perforated distributor plates 11 and 11' disposed in spaced parallel relationship, as more clearly seen in Figure 2, by an intermediate structure constituted by two rectangular separator plates 12 and 12' interconnected in back-to-back relationship, as hereinshown.

The rectangular separator plates 12 and 12' are better illustrated in Figures 5 and 6 and as hereinshown they are plates of undulated transverse cross-section, herein of a zigzag, triangular or sine wave configuration defining longitudinal peaks 13 and longitudinal valleys 14. The separator plates are interconnected in back-to-back relationship at their peaks 13, as shown in Figure 2, whereby to form therebetween a plurality of adjacent cooling liquid channels 15. Usually water is circulated through these channels to cool the assembly. These interconnected separator plates also define on opposed outer faces thereof a first group of outer gas distribution channels 16 and a second group of such channels 17. These channels 16 and 17 are utilized to circulate hydrogen on one side of the assembly and an oxidant, such as air, on the other side.

As shown in Figure 3, the perforated distributor plate 11 has about 50% of its flat top surface 18 perforated with holes 20. These holes 20 extend over the first and second group of outer gas channels 16 and 17, respectively. These holes can have a number of shapes such as round, hexagonal square, etc. Accordingly, gas fed through the groups of gas channels will permeate through the distributor plates substantially uniformly therealong as the groups of gas channels are unobstructing straight channels extending from opposed end edges 19 and 19' of the assembly, as shown more clearly in Figures 7 and 8.

As also shown in Figures 3 and 4, the perforated distributor plate 11 is formed with a stepped longitudinal edge flange 21 and extend from a rear side surface 18' of

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the distributor plates. The two rectangular separator plates also have longitudinal connector flanges 22 on opposed side edges thereof and as shown in Figures 7 and 8, these flanges are welded together and sandwiched between the longitudinal edge flange of opposed perforated distributor plates 11 and 11' and welded together by longitudinal line resistance welding, as shown at 24. The zigzag separator plates are interconnected together at their juxtaposed peaks 13 and welded on the flange 22. These separator plates may be made of very thin stainless steel, aluminum, numerous alloys or it is even contemplated that plastic could be used in their fabrication. Their shape could be easily formed by rolling, cold forming or other processes and then cut to size.

Referring now to Figures 1 and 9 to 12C, there is shown the construction of the end manifolds 25 and 25' connected to each end of the plate assembly illustrated in Figure 7. The distribution end manifolds 25 and 25' provide a seal between the hydrogen gas, oxidant gas and cooling liquid channels. The manifolds may be made of plastic material, and therefore molding these manifolds would be low cost with the proper material selection and geometry contributing to the sealing. Metallic manifold materials are equally feasible and many alternatives are possible for providing the sealing.

As shown in Figures 10A and 10B, the end distribution manifolds 25 are provided with connector channels 29, 29' and 29" extending along the manifold and receive the hydrogen gas, water cooling and oxidant. The connector channels 29, 29' and 29" have gas and cooling liquid supply holes 26, 26' and 26". In Fig. 9 is shown the zigzag cavities 33 (which receive the ends of the separator plates) and rectangular cavities 34 which receive an edge portion of the perforated distributor plates 11. The cavity 35 receives the sandwich created by the flanges 21, 22 welded together (Fig. 8). The ends of the assembly as shown



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in Figure 7 is press-fitted in these cavities and sealed therein.

The groups of channels 29, 29' and 29" are connected to respective inlet ports 28, 28' and 28" to admit the gases and the cooling liquids in these channels. The ports in the other connectors would be outlet ports or vise-versa, whereby to provide for the convection of hydrogen gas, an oxidant gas such as air, and a cooling liquid, such as water across the channels from opposed ends thereof. With this construction, the hydrogen gas and oxidant channels are isolated from one another by the water cooling channels 15, formed by the zigzag separator plates 12 and 12'.

As shown in Figures 10 to 12C, each of the inlet ports 28, 28' and 28" are connected to longitudinal straight interconnecting conduits with conduit 29 being connected to the port 28 and to the end of the first group of channels 16, conduit 29' being connected to the inlet port 28' and to the cooling liquid, herein water supply, and the longitudinal conduit 29" being connected to the port 28" to admit either the hydrogen or the oxidant gas.

When these bipolar separator plate assemblies are interconnected in stack relationship, as shown in Figures 13-15, their inlet and outlet ports 28, 28' and 28" are all interconnected together in a fashion as shown in Figure 14A via common distribution conduits 30 provided for each group of channels and as more clearly illustrated in Figures 12A to 12C. Of course, in the construction of a fuel cell, membrane electrode assembly sheets are also interposed between these plates to form contact across which a potential is developed by electro-chemical reaction between the hydrogen and oxidant, as is obvious to those skilled in the art. Hydrogen gas and oxidant gas distribution devices and cooling liquid pumps and collectors also form part of a fuel cell assembly and are not illustrated herein, but are also obvious to a person skilled in the art.

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It is within the ambit of the present invention to cover any obvious modifications of the preferred embodiment described herein provided such modifications fall within the scope of the appended claims.

## CLAIMS:

1. A liquid cooled bipolar separator plate assembly for a fuel cell comprising a pair of rectangular perforated distributor plates disposed in spaced parallel relationship by an intermediate structure, said intermediate structure having inner cooling liquid channels and a first and a second group of outer exposed gas distribution channels on opposed outer sides of said intermediate structure, said outer channels being separated by ridges which are secured to a respective one of said perforated distributor plates, said perforated distributor plates and intermediate structure being sealingly secured together along their opposed side edges, said inner cooling liquid channels and said outer gas channels being opened at opposed end edges of said intermediate structure and distributor plates, and an end distribution manifold sealingly secured to each of said opposed end edges, said end manifolds each having interconnecting conduits to interconnect said cooling liquid channels together and said first and second groups of gas channels, respectively, together.

2. A liquid cooled bipolar separator plate assembly as claimed in claim 1 wherein said intermediate structure is constituted by two rectangular separator plates of undulated transverse cross-section with each plate defining longitudinal peaks and valleys, said separator plates being interconnected in back-to-back relationship at said peaks to form an inner cooling channel therebetween and disposed in parallel side-by-side relationship.

3. A liquid cooled bipolar separator plate assembly as claimed in claim 2 wherein said gas distribution channels being defined by said valleys between said peaks, said peaks constituting said ridges.

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4. A liquid cooled bipolar separator plate assembly as claimed in claim 3 wherein said separator plates are metal plates formed with an undulating wave cross-section.

5. A liquid cooled bipolar separator plate assembly as claimed in claim 3 wherein said perforated distributor plates have about 50% perforations in a surface portion thereof disposed adjacent said first and second group of outer gas channels.

6. A liquid cooled bipolar separator plate assembly as claimed in claim 3 wherein said separator plates are connected together and to said distributor plates by longitudinal line resistance welds to form sealed interconnections.

7. A liquid cooled bipolar separator plate assembly as claimed in claim 6 wherein said separator plates are provided with flat longitudinal connector flanges along opposed longitudinal side edges thereof, said perforated distributor plates having a stepped longitudinal edge flange disposed on a common side of a rear surface of said distributor plate, said two rectangular separator plates having said longitudinal connector flanges interconnected in juxtaposed relationship and sandwiched between said edge flanges of said opposed distributor plates in sealing relationship.

8. A liquid cooled bipolar separator plate assembly as claimed in claim 7 wherein said first and second group of outer exposed gas channels are isolated from one another by said group of inner adjacent water cooling channels interposed therebetween in sealing relationship and providing heat exchange with said gas channels.

9. A liquid cooled bipolar separator plate assembly as claimed in claim 1 wherein said end manifold

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interconnecting conduits comprise a cooling liquid interconnecting conduit interconnecting adjacent open ends of said inner cooling liquid channels together, one of said end manifolds having an inlet port leading to interconnecting conduits of said cooling liquid distribution channel, the other of said end manifolds having an outlet port leading to interconnecting conduits of said cooling liquid distribution channel whereby a cooling liquid may be convected through said inner cooling liquid channels from one end to the opposed end thereof without obstruction.

10. A liquid cooled bipolar separator plate assembly as claimed in claim 9 wherein said interconnecting conduits further comprise hydrogen gas interconnecting conduits to interconnect adjacent open ends of said first group of outer channels, and oxidant gas interconnecting conduits to interconnect adjacent open ends of said second group of outer channels, and an inlet gas port in one of said manifolds and an outlet gas port in the other of said manifolds leading to associated interconnecting conduits to provide a hydrogen and oxidant gas flow directly across said first and second groups of outer gas channels, respectively.

11. A liquid cooled bipolar separator plate assembly as claimed in claim 10 wherein said end manifolds are molded from plastics material or metal die-casted.

12. A liquid cooled bipolar separator plate assembly as claimed in claim 9 wherein said cooling liquid is water.

13. A liquid cooled bipolar separator plate assembly as claimed in claim 7 wherein said interconnected longitudinal connector flanges and stepped longitudinal edge flange form a longitudinal flanged heat sink.

14. A fuel cell incorporating a stack of liquid cooled bipolar separator plate assemblies as defined in claim 10

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and wherein like inlet and outlet ports of said end manifolds of said stack are interconnected together to form common gas and cooling liquid inlet channels.

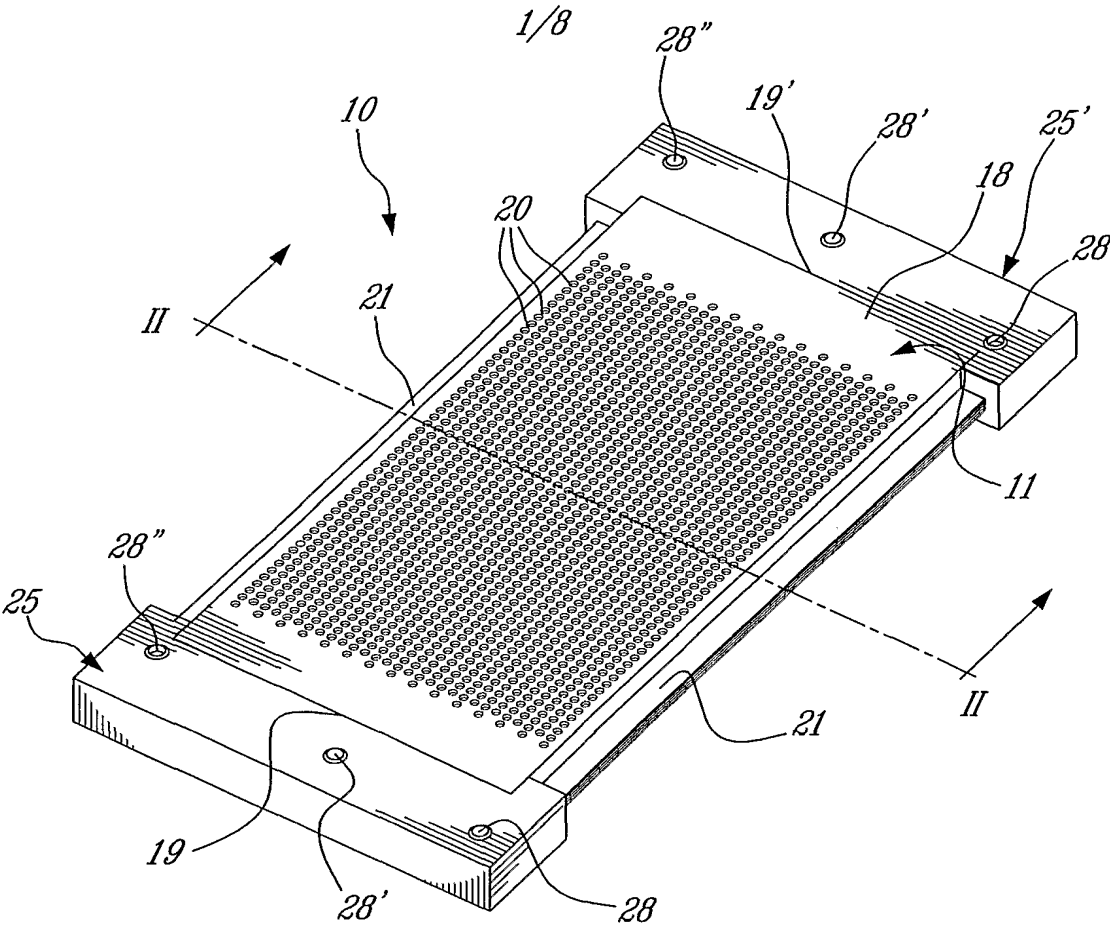


FIG. 1

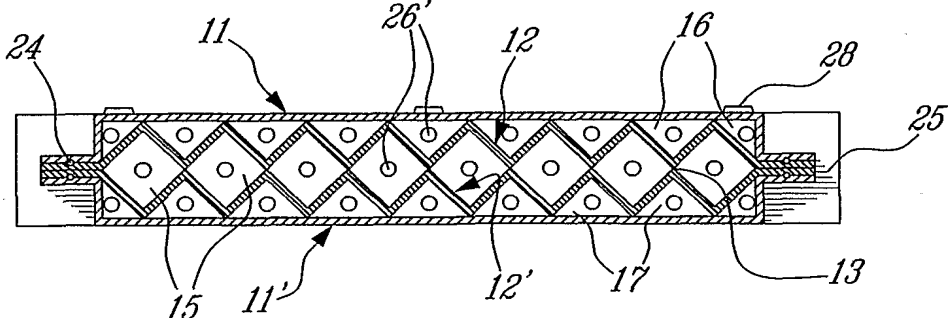


FIG. 2

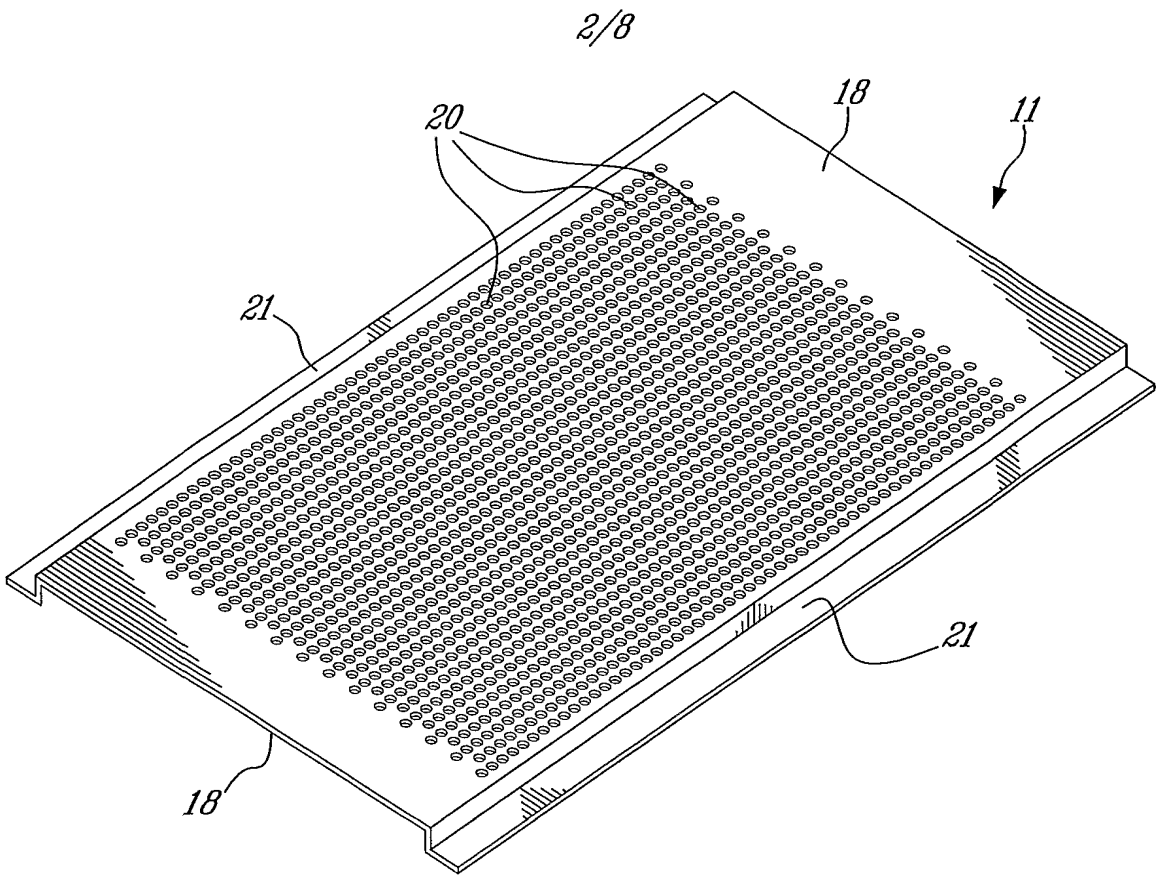


FIG. 3

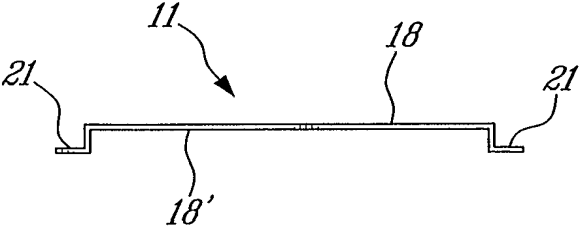


FIG. 4



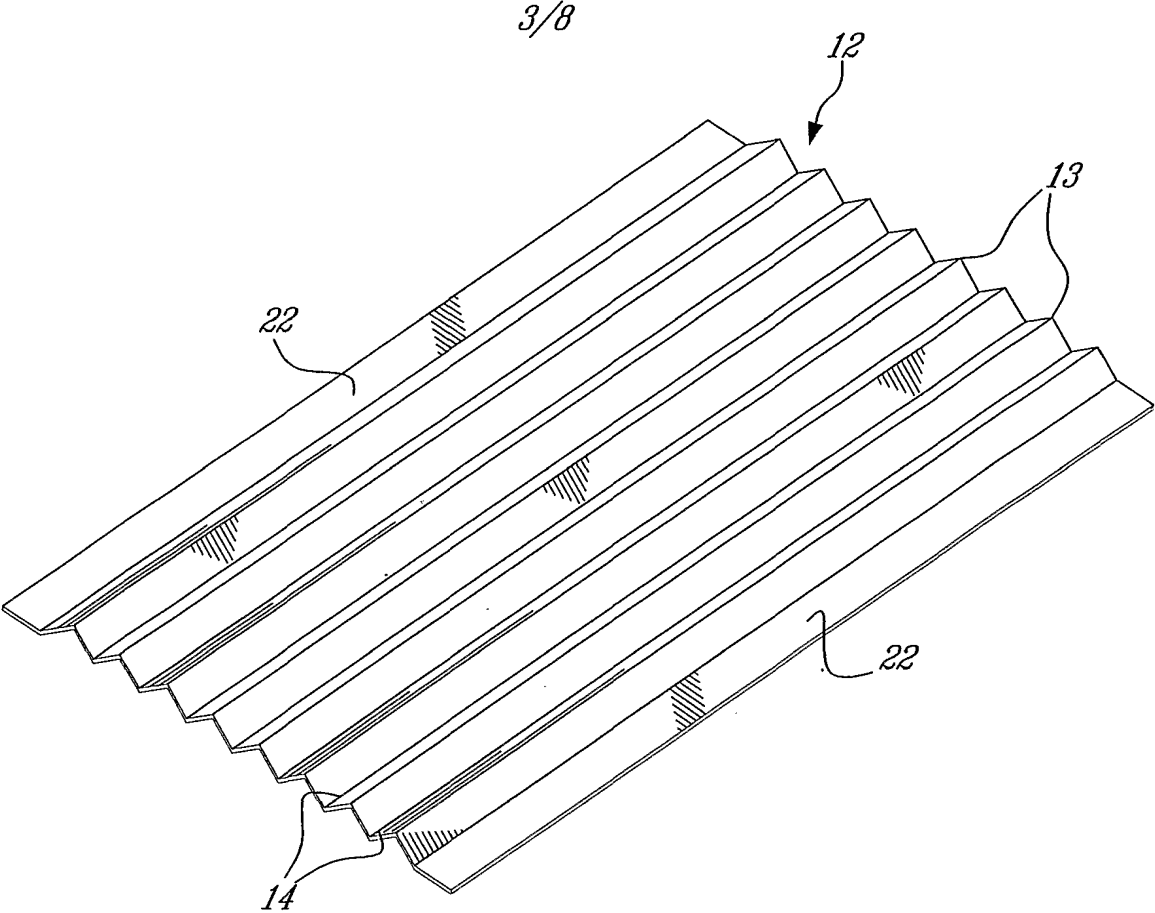


FIG. 5



FIG. 6

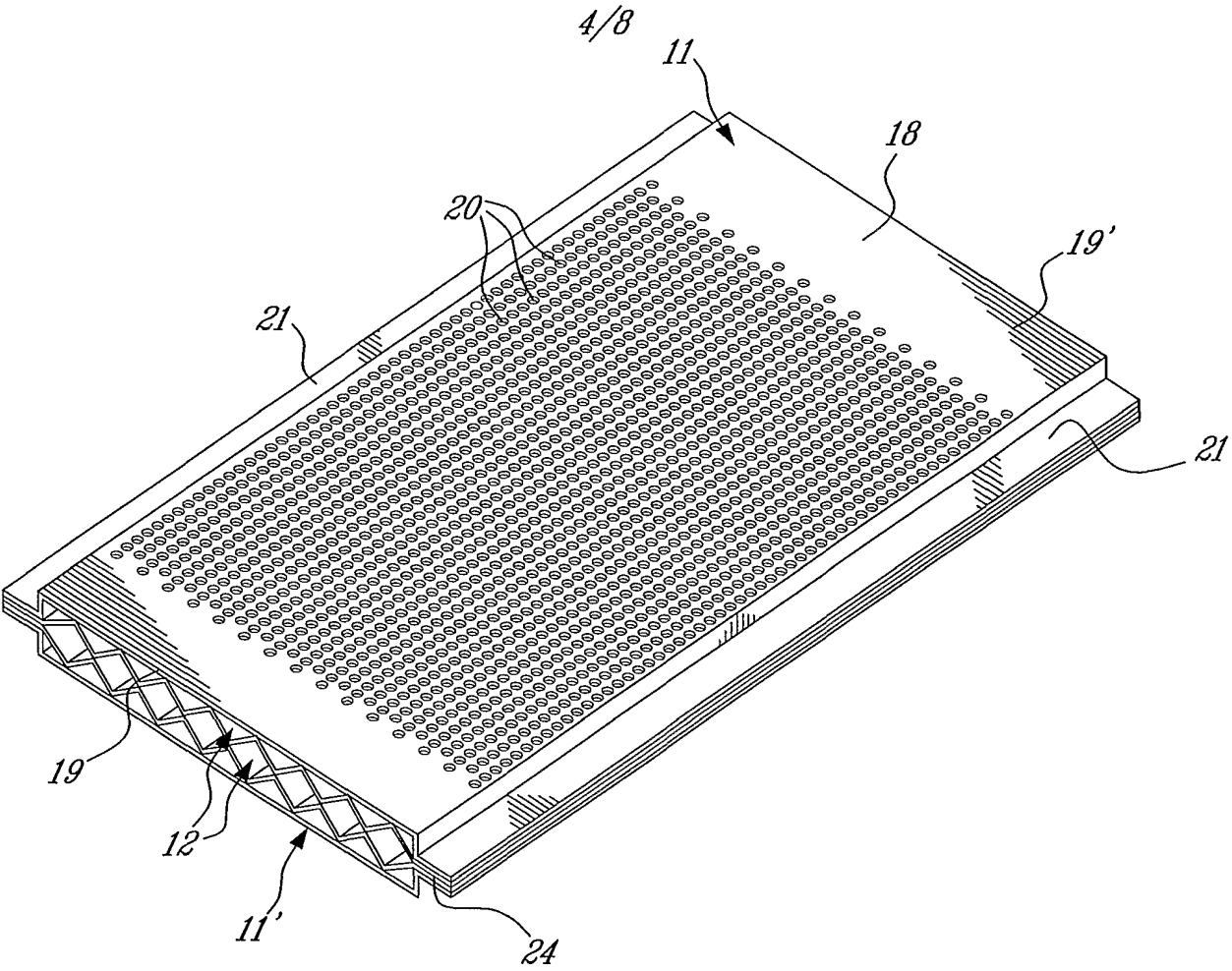


FIG. 7

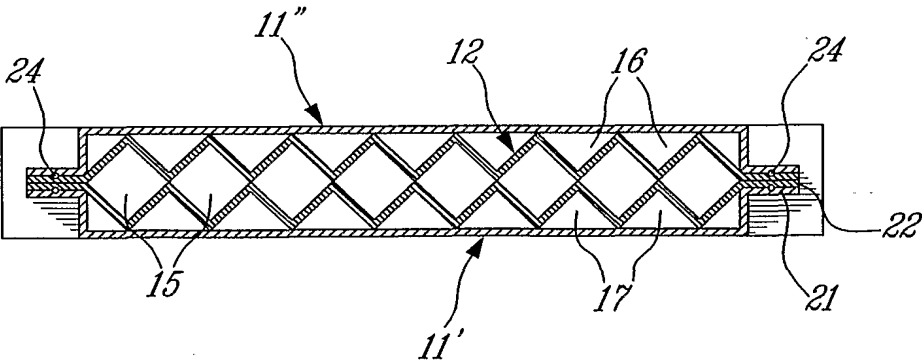
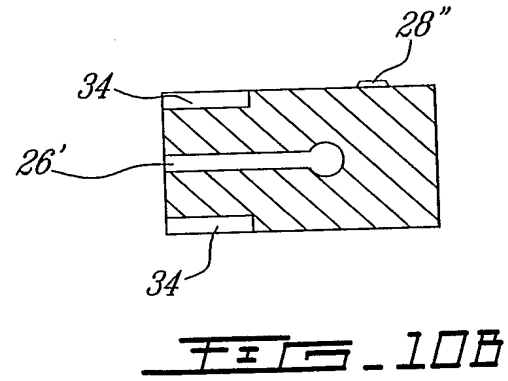
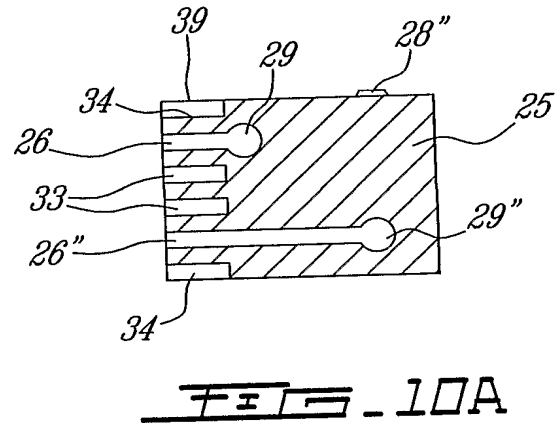
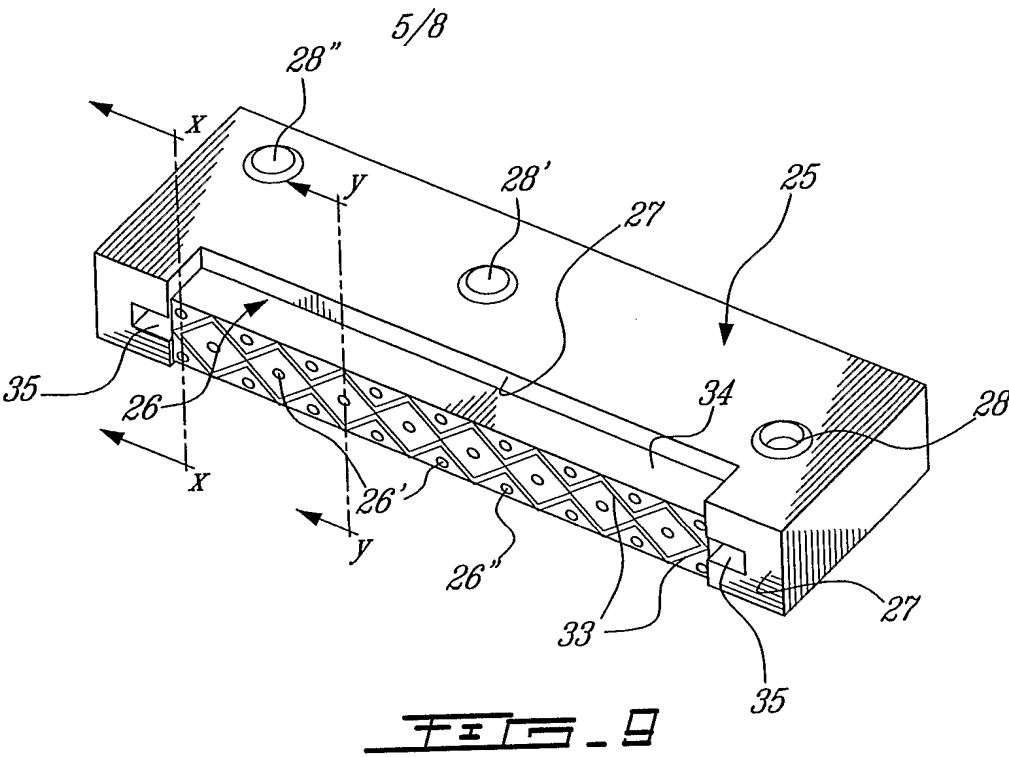
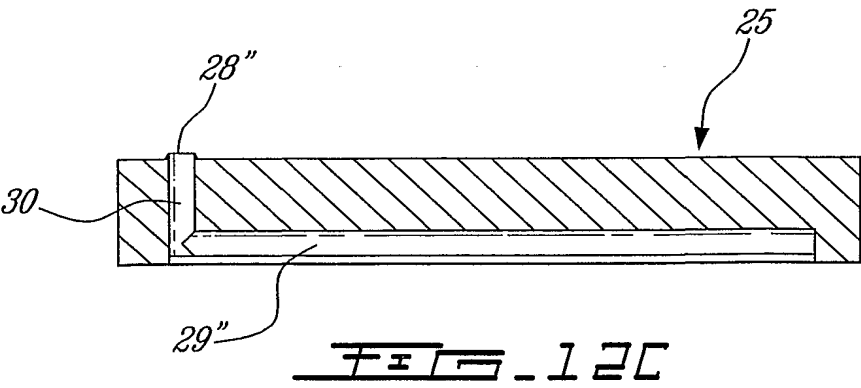
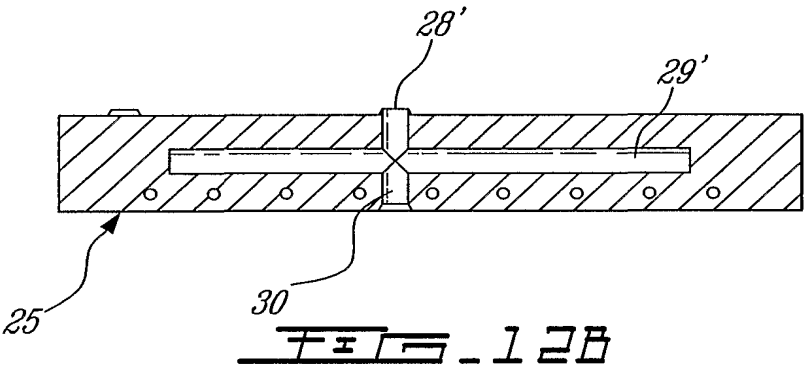
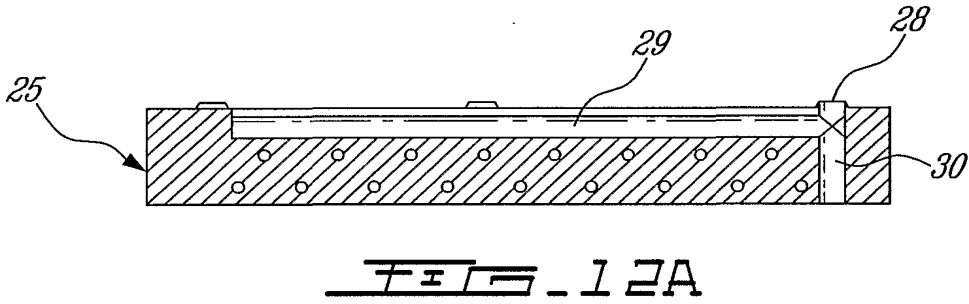
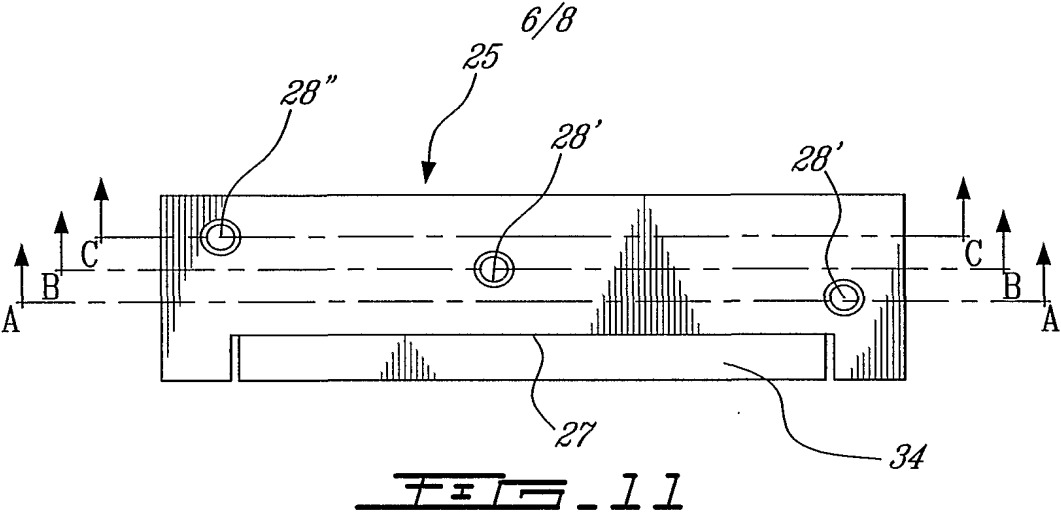


FIG. 8





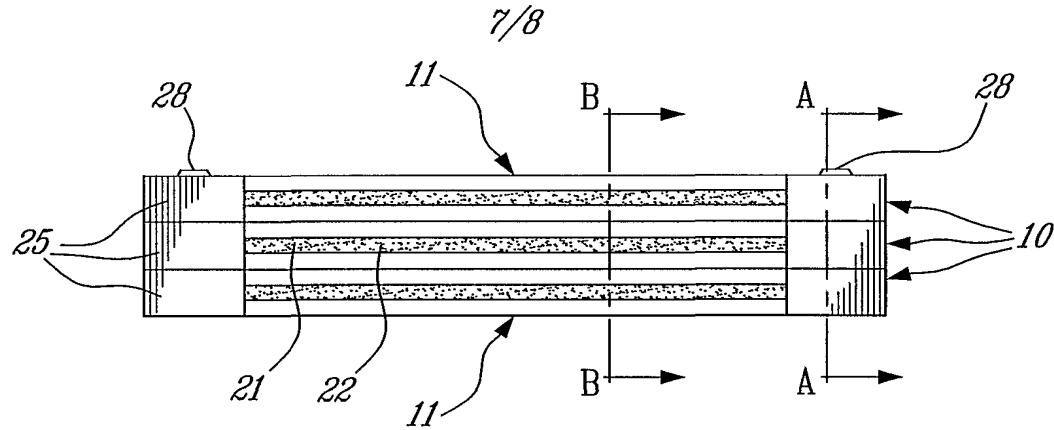


FIG. 13

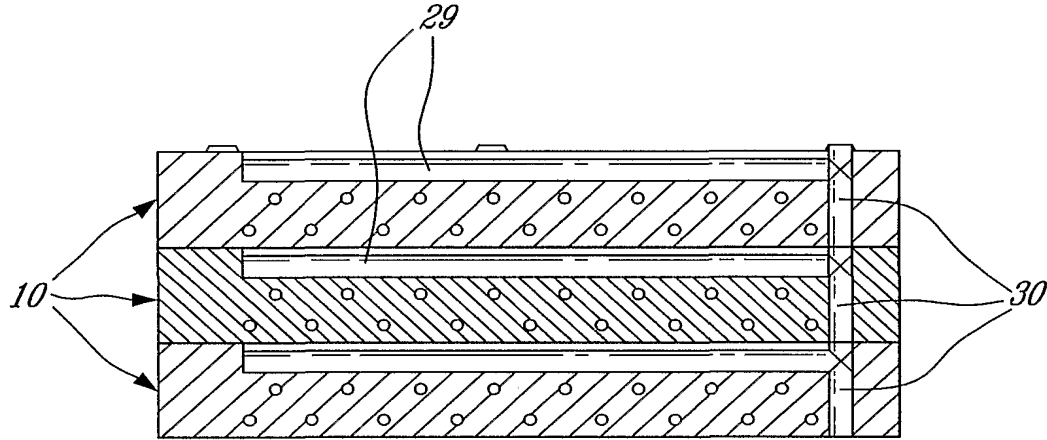


FIG. 14A

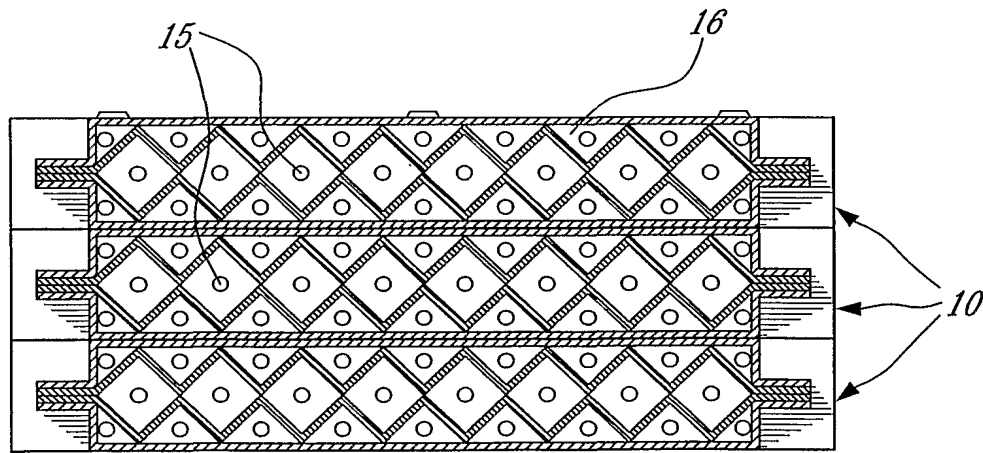


FIG. 14B

